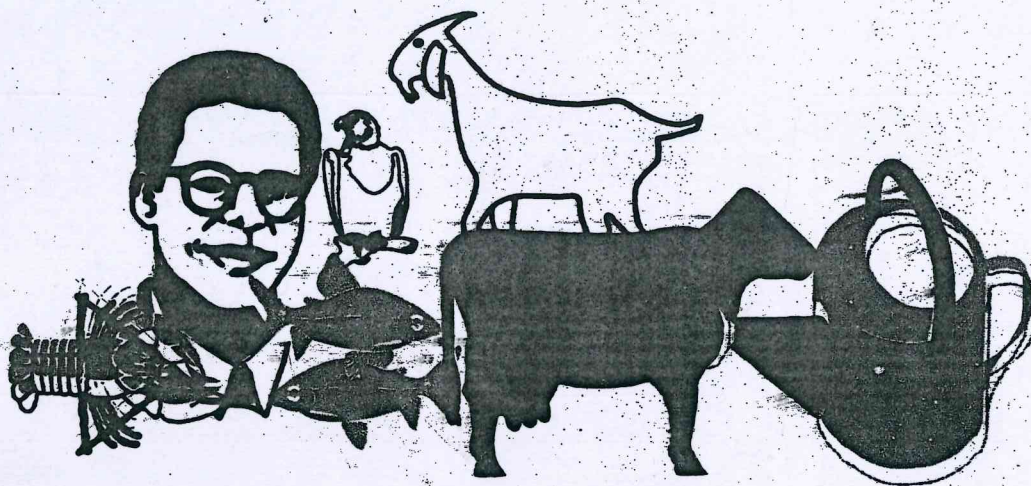


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COWPEA GROWTH AND YIELD PERFORMANCE AS INFLUENCED BY PHOSPHORUS NUTRITION IN THE SOUTHERN GUINEA SAVANNA ZONE OF NIGERIA

BY

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ABSTRACT

The major constraint to increasing on-farm production of cowpea, getting the optimum yield and the widespread cultivation of the crop in the forest and savannah region is the limitation posed to it by phosphorus nutrition. Therefore, this study was carried out to determine the optimum level of phosphorus for better growth and yield of cowpea. The experiment was conducted at the Teaching and Research farm of the Faculty of Agriculture, University of Ilorin. Five levels of phosphorus fertilizers (0kgP/ha, 30kgP/ha, 60kgP/ha, 90kgP/ha, 120kgP/ha) were used in the study and the experiment was laid out in a Randomized Complete Block Design with three replications. Data on plant height, number of leaves, number of branches, number of flowers and number of pods were taken. All the data collected were analyzed using analysis of variance and significant means were separated using LSD with the aid of GENSTAT 5.2 statistical package. The results showed that phosphorus fertilizer at the rate of 30kgP/ha and 60kgP/ha could significantly improve number of leaves, number of branches, number of flowers and grain yield of cowpea at $P < 0.05$. It is therefore, recommended that application of phosphorus fertilizer at 30kg/ha be used to enhance grain yield because it is more economically viable than 60kgP/ha to achieve the same objective.

Key words: Cowpea, phosphorus nutrition, soil fertility, growth and yield improvement.

INTRODUCTION

Cowpea (*Vigna unguiculata*, L. (Walp)) is a popular staple food that belongs to the family Fabaceae. The seeds are a major source of plant proteins and vitamins for both man and animals, and also a source of cash income. The young leaves and immature pods are eaten as vegetables (Dugje *et al.*, 2009). Due to its ability to fix atmospheric nitrogen, cowpea grows better than soybeans on soils low in fertility and as well as sandy soil and can also be used for soil improvement. Based on this, cowpea plays an important role in providing soil nitrogen to cereal crops such as maize, millet, and sorghum when grown in rotation, especially in areas where poor soil fertility is a problem. It does not require high rate of nitrogen fertilization because its roots have nodules in which soil bacteria called *Rhizobia* help to fix nitrogen from the air (Dugje *et al.*, 2009).

Although cowpea can grow well on less fertile soil and on sandy soil, its performance can be improved with application of phosphorus and potassium fertilizers because the two are for nodulation and yield improvement respectively (Dugje *et al.*, 2009).

The importance of phosphorus (P) to cowpea growth cannot be over-emphasized because it is one of the most important nutrients required by the plant for high

productivity. Although a lot of plants require phosphorus in large quantity, the requirement of cowpea is small compare to them and it is critical to cowpea yield and nodulation (particularly for improved photoperiod-insensitive cultivars) because of its multiple effects on nutrition (Adetunji, 1995). Therefore, P deficiency becomes the most limiting soil fertility factor for cowpea production (Reamaekers, 2001).

Generally, all the phosphorus needed by plants is absorbed through the root system from the soil. A good and early supply of phosphorus provides a good foundation for the plant reproductive part and so, it helps production of vibrant reproductive structures in the plant. It has been established that phosphorus is also essential for early maturity of crops and for seed formation and, therefore, it is found in large quantity in seeds and fruit. In addition, phosphorous increases root growth and photosynthesis. As against the normal expectation of linear relationship between application rate and yield gain, cowpea response to different levels of phosphorous results in nutrient imbalance and the law of minimum gets its effect, application is high (Asiwe, 2009). High levels of phosphorus in the soil tend to increase the proportion of available calcium and magnesium in seeds which are required for strong bone and healthy blood respectively in man (Olufemi *et al.*, 2010).

Despite the calls for a reduced dependence on chemical fertilizers (Parr *et al.*, 1990; Rodale, 1995), the very slow action of organic fertilizer, has continued to necessitate the use of mineral fertilizer to cater for immediate request of the plants. Essentially, plant response to nutrient elements varied and ecology specific. Abayomi *et al* (2008) has worked on the effect of nitrogen fertilizer in form of NPK on different cowpea varieties in the Southern Guinea Savanna Zone of Nigeria. The present work used single superphosphate as a source of phosphorous (P) nutrition for cowpea on Ife Bimpe variety, the study of which has a dearth of information in this ecological zone.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research farm of the Faculty of Agriculture, University of Ilorin. Soil samples of the experimental land were randomly taken in a systemic manner from the top 0-15cm depth and bulked together to get a composite sample. The sample was air dried for three days after which it was passed through a 2mm sieve and analyzed for its physical and chemical characteristics.

Soil samples of the experimental field were systemically taken before planting and using soil auger at the depth of 0-20cm. The samples were bulked to obtain a composite sample which were subsequently passed through 2mm sieve and analyzed for their physico-chemical characteristics. The physico-chemical characteristics of the the soil revealed that the textural class of the soil was loamy sand because it was made up of 83.52% sand, 8.00% silt and 8.48% clay respectively. The soil also contained 1.2mg/kg available phosphorus, 1.4Cmol/kg calcium, 0.9Cmol/kg magnesium, 1.8 Cmol/kg potassium, 1.2 Cmol/kg sodium, 0.05g/kg nitrogen and pH of 6.2 (determined in water). Thus, the soil was low in phosphorus and other micro nutrients.

The experiment involved the use of five treatments replicated three times. The treatments were 0, 30, 60, 90 and 120kgP/ha in form of single superphosphate represented by T1, T2, T3, T4 and T5 respectively. The layout of the experiment was

Randomized Complete Block Design. Each plot had an area of 9m^2 with dimension of $3\text{m} \times 3\text{m}$. Ife Bimpe cowpea variety was obtained from The National Seed Service, Ibadan, and planted at the rate of two seeds per hole with spacing of 1.2m by 0.3m . The single superphosphate fertilizer was applied at exactly 3 weeks after planting (WAP) using spot application method buried at depth of 4cm on one side of each plant.

Insect pests were controlled by weekly application of insecticide called *Marshall* containing Lambda-cyhalothrin 2.5 EC as soon as flowers emerged until pod maturity. The insecticide was applied at a rate of 0.6 l/ha . Weeds were manually controlled with hoe throughout the span of the experiment to forestall inter-specific competition between the crop and the weeds.

Data collection began five weeks after planting. Data collected included plant height, number of leaves per plant, and number of branches per plant, number of flowers per plant, number of pods per plant, number of seeds per pod, number of pods per plant, pod weight, economic yield and shelling percentage which was calculated as follows:

$$\text{Shelling \%} = \frac{\text{Grain weight}}{\text{Pod weight}} \times 100\%$$

All data collected were statistically analyzed using Analysis of Variance (ANOVA) with the aid of Genstat 5 and significant means were separated using Least Significant Difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

The number of leaves was affected by P fertilization at all levels of treatment with the highest and significant increase found in T3 throughout the growth period. The linear increase was noticed from all the treatments until the penultimate week of data collection where decline was witnessed in all the treatments. The percentage increases in leaf production of T3 over the control from the first week of observation to the end were 64.29, 28.57, 29.17 and 283.33% respectively (Table 2). The highest number of branches was produced by T3 also across board, while the control had the least. The increases were respectively 150, 100, 50 and 60% from the beginning to the end of the observation (Table 3). The positive effect of P fertilization on leaf production at 60kgP/ha could be attributed to nutritional balance in the system of the crop. The decline in the number of leaves appearing at the end of the data period was as a result of leaf senescence which resulted from plant disturbance during data collection. The higher the number of leaves the better the canopy production and the light interception for photosynthetic activities which will lead to higher production of assimilates. The effective partitioning of assimilates into the grains during grain filling increases yield and finally harvest index. Furthermore, better leaf production is an index of higher transpiration rate if all other conditions are kept constant. This then led to better absorption of water and nutrient for luxuriant growth and consequential yield improvement that was observed. Also, a balanced soil nutrients which was the result of adding P fertilizer enhanced root growth and consequently higher rate of absorption of water and nutrient which favoured better vegetative growth (stem and leaves). Increase in the number of petioles, pods, nodules,

number of leaves, leaf area, pods, seeds per pod and the final yield shows that P is an important element influencing cowpea performance (Owolade *et al.*, 2006). The vegetative growth and development hinge on better nutrition of the plant. The optimum application of P in this work led to production of higher and significant number of branches which determines the number of leaves that could be supported by the concerned plant. The significant increase in the number of branches as well as the number of leaves by 60kgP/ha revealed that there was a linear relationship between the two of them. Higher number of branches increases the number of leaves and hence canopy architecture so that there would be higher solar energy interception for better photosynthetic activities which will produce the required food that will be partitioned effectively to achieve higher yield.

Table1: Effect of phosphorus fertilization on number of flower produced

Treatments (kg/ha)	Weeks After Planting(WAP)				
	7WAP	8WAP	9WAP	10WAP	11WAP
T1	2.00	3.00	6.00	6.00	1.00
T2	3.00	10.00	4.00	6.00	2.00
T3	4.00	9.00	5.00	4.00	1.00
T4	3.00	8.00	5.00	6.00	3.00
T5	2.00	7.00	4.00	7.00	3.00
LSD (0.05)	1.518	1.786	1.518	ns	ns

T1=0kgP/ha, T2=30kgP/ha, T3=60kgP/ha, T4=90kgP/ha and T5=120kgP/ha

Table 2: Effect of phosphorus fertilization on number of leaf produced

Treatments (kg/ha)	Number of Leaves			
	5WAP	7WAP	9WAP	11WAP
T1	14.00	21.00	24.00	6.00
T2	19.00	26.00	30.00	19.00
T3	23.00	27.00	31.00	23.00
T3	17.00	25.00	28.00	13.00
T5	16.00	20.00	25.00	10.00
LSD (0.05)	4.495	3.179	4.528	4.495

T1=0kgP/ha, T2=30kgP/ha, T3=60kgP/ha, T4=90kgP/ha and T5=120kgP/ha

P fertilization also had a significant influence on the plant height from T3. The percentage increases were 15.26, 29.31, 54.66 and 57.50% respectively from the first reading to the end (Table 4). Majorly the height of a plant is highly affected by nitrogen content of the soil. But when there is imbalance in soil nutrient, the plant may become stunted. The same optimum that has been given positive and significant increase in all other vegetative parts in this work was also responsible for this observation. The result here could be as a result of higher mitotic division at the apical meristem of the shoot for higher height and at the apical meristem of root for better absorption of water and nutrient that support the nutrient requirement of the dividing cells at the tips. Tenebe *et al.*, (1995) established that increase in height and vegetative growth of cowpea lines were the results of increase in P application in the soil.

The peak of flower production was observed at eighth week after planting (WAP) and the highest number was found from T2 and closely followed by T3 also. The two were significantly higher than T1 (control). T3 and T2 were 233.00 and 200.00% respectively higher than the control. After this stage, there was decline in the number of flowers observed (Table1). The highest number of pods was also from T3 and was significantly improved over the control. The percentage increases over the control were 200.00, 266.67, 133.33, 112.50, 85.71, and 270.00% respectively over the period of observation (Table 5). The highest number of grain yield was recorded from T2 and T3. They were 73.51% better than the control and the increase was equally significant (Table 6). Lower P fertilizer rates enhanced flower production in cowpea according to the report of this experiment. The progressive decrease in the number of flowers in all the treatments was as a result of fertilization and the development of the flowers into fruits (pods). In some other cases, it was due to abortion when fertilization failed to occur. The rate of disappearance of the flowers is directly proportional to velocity of pod production. The significant effect produced by P application came as a result of moderate P nutrition needed by the plant and its being second important element for crop production after nitrogen. The effectiveness could be attributed to the ability of moderate P nutrition to check the luxuriant vegetative growth which would be at the expense of reproductive stage of the plant. Since cowpea produced enough nitrogen to cater for its vegetative and physiological maintenance, little P nutrition was therefore, a requirement for fulfilling the reproductive need. 30 and 60kgP/ha were the lowest levels among the applied treatments which favoured significant higher flower production. This is an index of pod production because higher flower production results in higher pod number if abortion does not follow fertilization. Also, the rate at which the flowers turned to pod was higher where lower P nutrition was applied. This becomes advantageous because the pod production becomes uniform and harvesting is eased because of the synchronization of the pod produced and their maturity. The higher levels which were less effective on the number of flower produced could be the result of the toxicity and nutrient imbalance produced by the additional P fertilizer which therefore caused nutrient imbalance and consequently less number of flowers than the result of the optimum application.

Table 3: Effect of phosphorus fertilization on branch production in cowpea

Treatments (kg/ha)	Number of Branches			
	5WAP	7WAP	9WAP	11WAP
T1	2.00	3.00	5.00	6.00
T2	4.00	5.00	6.00	8.00
T3	5.00	6.00	8.00	9.00
T4	4.00	4.00	6.00	7.00
T5	3.00	4.00	6.00	6.00
LSD (0.05)	1.191	1.166	1.286	0.6875

T1=0kgP/ha, T2=30kgP/ha, T3=60kgP/ha, T4=90kgP/ha and T5=120kgP/ha

Table 4: Effect of phosphorus fertilization on height of cowpea(cm)

Treatments (kg/ha)	Weeks after planting			
	5WAP	7WAP	9WAP	11WAP
T1	15.47	17.30	18.90	19.13
T2	17.30	18.90	24.63	25.37
T3	17.83	22.37	29.23	30.13
T4	16.63	19.10	21.80	23.27
T5	16.17	18.30	20.37	21.33
LSD (0.05)	1.304	1.612	3.678	3.416

T1=0kgP/ha, T2=30kgP/ha, T3=60kgP/ha, T4=90kgP/ha and T5=120kgP/ha

Table 5: Effect of phosphorus fertilization on pod production in cowpea

Treatments (kg/ha)	Number of Pods					
	6WAP	7WAP	8WAP	9WAP	10WAP	11WAP
T1	0.00	3.00	9.00	8.00	7.00	2.00
T2	2.00	8.00	14.00	8.00	13.00	6.00
T3	2.00	11.00	21.00	17.00	13.00	7.00
T4	1.00	7.00	13.00	11.00	10.00	5.00
T5	0.00	6.00	14.00	9.00	10.00	3.00
LSD (0.05)	1.166	2.640	5.984	6.301	ns	2.947

T1=0kgP/ha, T2=30kgP/ha, T3=60kgP/ha, T4=90kgP/ha and T5=120kgP/ha

Table 6: Effect of phosphorus fertilizer on cowpea grain yield

Treatments (kg/ha)	Grain yield values (kg/ha)
T1	555
T2	963
T3	963
T4	852
T5	741
LSD (0.05)	183.1

T1=0kgP/ha, T2=30kgP/ha, T3=60kgP/ha, T4=90kgP/ha and T5=120kgP/ha

Pod production is consequential upon flower production and its fertilization if abortion is phased out. The highest flower production among the treatments would definitely produce the highest number of pod if all the above conditions are fulfilled. From this work, there was a positive correlation between flower production and the resultant pods produced. This could be attributed to better pollination and subsequent fertilization of the ovaries and the ovule which was accompanied by effective pests and diseases control that would have led to flower abortion. It is crystal clear that the optimum phosphorus level for better growth and yield of cowpea was 60kgP/ha because all the measured morphological parameters were positively increased by it and none was left out.

Finally the utmost target of crop production is the yield produced after all the morphological parameters have been enhanced. In the present research, there was linear relationship between flower, pod and grain production. Grain yield is not dependent on nitrogen fertilization which is adequately produced biologically by cowpea. 60kgP/ha was effective in checking the excesses of nitrogen in vegetative production at the expense

of the reproductive development of the plant which other levels of P were ineffective in achieving it. The yield realized here as result of positive influence of P nutrition was because the grain filling requires potassium and phosphorus their optimum levels and such has been fulfilled in this experiment. Moreover, the photosynthetic sites (leaves) were improved by P nutrition and therefore more assimilates were produced. These were effectively partitioned into the developing grains and that finally led to yield increase. Very striking was the par yield production by 30kgP/ha which was not effective in enhancing the rest parameters of growth and reproduction. This still establishes the fact that lower P nutrition would be the best option for cowpea production and nothing beyond 60kgP/ha could be of any benefit but unnecessary increase in cost of production and an accompanied yield reduction as could be seen from this work. Magani and Kunchi (2009) attributed yield increase through P fertilization to increase in leaf area, plant height and number of branches. Although the performance of all P-levels could be better than the control (0 kg P_2O_5 ha⁻¹) in their yield components of cowpea which suggests the important role of phosphorus in its grain production (Asiwe, 2009) lower grain yields than expected could result from higher level of P nutrition which was possibly due to the effect some nutrient imbalance because other macronutrients and micro-nutrients were not at their optimum levels and the less optimum nutrients then become the limiting factors (Ntare and Bationo, 1992, Ankomah et al., 1995, Vadez et al., 1999, Waluyo et al., 2004). This explanation is an elucidation of Liebig's law of minimum. It is therefore, concluded that application of P fertilizer between 30 and 60kg/ha will be of economic benefit to cowpea producers through better morphological characteristics and yield increase.

CONCLUSION AND RECOMMENDATIONS

The application of P fertilizer between 30 and 60kg/ha will be of economic benefit to cowpea producers through better morphological characteristics and yield increase. It is recommended that application of phosphorus fertilizer at 30kg/ha be used to enhance grain yield in Ilorin and Guinea savannah because it is more economically viable than 60kgP/ha to achieve the same objective.

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